

In considering the accumulation of power from response stations, the Petitioners believe that it will be appropriate to modify the methodology advanced in Appendix C to the Petition to reflect that in many cases, the access protocol to be employed only permits a single response station to operate on a given channel at a time within a given sector, as is the case with TDMA. Since only a single response station will be operating per sector, per frequency, the Petitioners believe it will be possible to identify the potential for interference from response stations associated with a proposed hub simply by accumulating the combined signals on all frequencies from the grid point on which a transceiver would be most likely to cause interference. In other words, since within each sector only a single response station can operate at a given time on a given frequency, there is no need to accumulate the signals of multiple response stations within the sector as if they would operate simultaneously on the same frequency. The Petitioners are exploring appropriate revisions to Appendix C to reflect this simplification, and will submit a more formal proposal shortly.

3. *The Proposed Rules For Protecting Response Station Hubs Can Be Modified To Provide A More Appropriate Level Of Interference.*

In crafting interference protection rules for return paths, the Petitioners sought to assure that response station hubs would be fully protected against interference. Because the response station hub is the “nerve center” of a two-way system, interference to a hub can be catastrophic. Thus, the Petition proposed an extremely conservative approach towards protecting response station hubs.

However, the Commission has questioned the concept of allowing each applicant for a response station hub to specify the minimum received signal level the proposed response station hub can utilize in the provision of service and to require subsequent applicants to employ that level in

predicting interference to the hub.<sup>105/</sup> Although the Petitioners continue to believe that their approach has value, on reflection the Petitioners agree with the Commission's implicit concern that an applicant could specify an inappropriate required receive signal level in order to secure undue protection to the response station hub.

The *NPRM* also solicits comments on concerns that the proposed rules over-protect response station hubs by requiring that in measuring compliance with the 45 dB/0 dB interference protection rations, subsequent applicants assume the use of a unity gain, omnidirectional plane polarized reception antenna at the hub.<sup>106/</sup> Although the objective of the Petitioners' proposal is to assure that hub designs can evolve to meet expanding demand for two-way services,<sup>107/</sup> the Petitioners recognize that it could have the effect of precluding service in adjacent markets by eliminating the ability of future applicants to employ cross-polarization and receive antenna discrimination to manage interference to a hub.

In response to these concerns, the Petitioners have revisited their proposed approach to analyzing the potential for interference to response station hubs. In the process, they have developed a new approach they believe will better balance the conflicting objectives of providing adequate protection to response station hubs while not unduly precluding new services by neighboring licensees. Because of the many tools that a response station hub licensee can employ to manage interference (such as increasing response station transmitter power, reducing cell size, reducing the

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<sup>105/</sup> See *NPRM*, at ¶ 43.

<sup>106/</sup> See *id.*

<sup>107/</sup> See Petitioners' Reply Comments, at 36-38.

modulation density utilized to serve a particular sector, reducing the width of a sector, and crosspolarizing response transmissions), the Petitioners believe that a response station hub can be protected without applying the 45 dB co-channel and 0 dB adjacent channel ratios usually applied to receive site protection. Rather, the Petitioners believe that hubs can be protected adequately merely by limiting the power flux density of the interfering signal received at each reception antenna previously installed or proposed for the hub, allowing for appropriate adjustments for cross-polarization.

Specifically, the Petitioners now propose that a response hub be deemed protected from interference when the power flux density generated by a neighbor (accumulating the signal of the primary station and any boosters or simultaneously-operated response stations) received by a hub antenna is no greater than -190 dBW/m<sup>2</sup>/Hz if the interfering signal is co-channel, or -151 dBW/m<sup>2</sup>/Hz if the interfering signal is adjacent channel, with a 20 dB adjustment in either case if the interfering signal is cross-polarized. The derivation of these proposed benchmarks follows.

Since, under the proposed rules all response facilities will employ digital modulation, interference to a hub receiver can be thought of as an increase in the receiver noise floor. When no interference is present, the noise floor is established through the thermal noise floor and is defined by the equation:

$$P_{\text{noise}} \text{ (dBW)} = 10\log[k\{^5/_9(T-32)+273\}BW] \quad (1)$$

where

k = Boltzmann's constant,  $1.380662 \times 10^{-23}$  ,  
T = Noise temperature in degrees Fahrenheit,  
BW = Bandwidth in Hz.

If we assume a bandwidth of 1 Hz and a temperature of 63 °F,<sup>108/</sup> the above equation will render a thermal noise power level of approximately -204 dBW/Hz.

When interference is caused by a digital transmission, it will appear as pseudo random noise to the desired signal and will create a relatively equal addition to the noise power within the interfering signal's bandwidth. With an analog interferor, the addition will not necessarily result in an even distribution of noise power across the bandwidth, because of the concentration of power within the modulated carriers. However, a worst case model for predicting interference from an analog signal would assume the peak power of the analog interfering signal exists at all points within the interfering signal's bandwidth. Therefore, whether the interferor is analog or digital it is reasonable to control interference to a hub site by controlling the increase in the noise floor at the hub receiver caused by interference from surrounding stations.

The maximum acceptable received signal level at a hub site can be determined by making reasonable yet conservative assumptions regarding the architecture of a hub. The received signal level at the input of the hub antenna from the interfering signal can be described by the equation:

$$R_{\text{hub}} = -G_{\text{hub}} + L_{\text{hub}} + 10 \log[10^{\{(P_{\text{noise}} + \text{NF} + P_{\text{increase}})/10\}} - \{10^{\{(P_{\text{noise}} + \text{NF})/10\}}] \quad (2)$$

where

$G_{\text{hub}}$  = Gain of the hub receive antenna in dBi,

$L_{\text{hub}}$  = Cable loss between the antenna and the downconverter in dB,

$P_{\text{noise}}$  = The thermal noise floor described in equation (1) in dBW,

NF = Noise figure of the downconverter in dB,

$P_{\text{increase}}$  = Allowed increase to noise floor from interference in dB.

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<sup>108/</sup> Assuming a fixed value for temperature is reasonable since varying the temperature by  $\pm 100$  degrees from 63 °F will cause less than  $\pm 1$  dB variation in the noise level.

A permissible limit on the amount of increase to the noise floor by the interfering signal must be set by the Commission so that system designers can allocate sufficient margins to handle the interference without unduly sacrificing system performance. The Petitioners submit that allowing a 1 dB increase in the noise floor caused by cochannel interference from any one neighboring licensee's primary station, booster stations and simultaneously-operating response stations is a reasonable standard.<sup>109/</sup> For example, if the hub noise floor were at  $-204$  dBW/Hz, a 1 dB increase in the noise floor would be generated by an interfering signal level of  $-209$  dBW/Hz.<sup>110/</sup> To simplify matters, the Petitioners suggest that typical values for the receive antenna gain, cable loss and noise figure of 13 dBi,<sup>111/</sup> 1 dB and 2 dB respectively be assumed. Therefore, equation (2) yields a maximum received signal level for an interfering signal of approximately  $-190$  dBm/Hz, which corresponds to a power flux density of  $-190$  dBW/m<sup>2</sup>/Hz.

Therefore, the Petitioners propose that the maximum allowable power flux density at the hub site generated by the aggregation of power from all simultaneously-operating transmitters of a cochannel licensee be fixed at  $-190$  dBW/m<sup>2</sup>/Hz for plane polarized calculations. For cross-

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<sup>109/</sup> It must be remembered there is likelihood this level of interference could be generated by several cochannel stations in surrounding markets. Two-way system designs will have to estimate the potential for a 1 dB increase from multiple sources and incorporate sufficient margins into their design.

<sup>110/</sup> See *Amendment of the Commission's Rules to Establish New Personal Communications Services*, 8 FCC Rcd 7700, at App. D (1993); *Amendment of the Commission's Rules to Establish New Personal Communications Services*, 9 FCC Rcd 4957, 5026 (1994).

<sup>111/</sup> Utilization of a typical receive antenna gain of 13 dBi to establish the maximum permitted level of the interfering signal does not unduly restrict either the design of the two-way system or the interference protection requirement of an adjacent market licensee.

polarized situations, the Petitioners recommend an additional 20 dB of fixed crosspolarization isolation be allowed, or so that the maximum allowable power flux density would be increased to  $-170 \text{ dBW/m}^2/\text{Hz}$ .

Adjacent channel interference can be handled in a similar manner. However, hub receivers will be able to tolerate significantly more adjacent channel interference than cochannel interference, since adjacent channel interference can be eliminated through improved filter design in the hub receiver.

By shifting a significant portion of the obligation for avoiding adjacent channel interference to the licensee of the response station hub, the maximum allowable level of interference can be determined by analyzing the noise requirements of the highest level modulation technique currently practical for use in this service -- 256-QAM. With 256-QAM, the theoretical minimum carrier-to-noise ratio requirement of a receiver is approximately 30 dB. However, the theoretical limit alone may not be sufficiently conservative to insure adequate protection of the hub. Because adjacent channel protection is far easier to control than cochannel, there is an increased potential for additional stations to exist and cause greater interference in the aggregate. Therefore, a reasonable proposal would be to add an additional 5 dB of margin to the theoretical limit and establish the desired adjacent channel carrier-to-noise requirement at 35 dB.

Since, as described previously, the noise floor without interference is  $-204 \text{ dBW/Hz}$ , adding 35 dB yields  $-169 \text{ dBW/Hz}$ . Again, considering the assumed 13 dBi receive antenna and 1 dB cable loss, the received signal level of the interfering signal at the input to the hub receive antenna would be  $-181 \text{ dBW/Hz}$  (or a  $-151 \text{ dBW/m}^2/\text{Hz}$ ) power flux density. Therefore, the Petitioners are

proposing the maximum allowable power flux density at the hub site generated by the aggregation of power from all transmitters (main, booster and response) of an adjacent channel licensee be fixed at  $-151 \text{ dBW/m}^2/\text{Hz}$  for plane polarized conditions and  $-131 \text{ dBW/m}^2/\text{Hz}$  in crosspolarized situations.

**D. The Potential For Interference Due To Downconverter Overload Feared By CTN Is Remote, And Can Always Be Cured.**

With the *Extension Order*, the Commission has specifically sought public comment on a proposal advanced by CTN that, although not entirely clear, apparently would limit commercial upstream transmission to MDS Channels 1 and 2/2A and the G and H Group channels, would limit ITFS return paths to the existing 125 kHz channels, and would require that a 24 MHz guardband exist between any response channel and any channel used for downstream transmissions.<sup>112/</sup> While

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<sup>112/</sup> See CTN Request, Joint Engineering Exhibit, at ¶¶ 7-8b. The Petitioners must admit to some confusion as to CTN's proposal regarding the use of the 125 kHz channels at 2686-2690 MHz, which CTN apparently is proposing be reserved solely for ITFS return paths.

The most significant area of confusion involves the disparity between CTN's belief that a 24 MHz guardband is required between upstream and downstream uses, and its proposal to permit ITFS licensees to operate response transmitters on 125 kHz channels that are within 24 MHz of G and H Group channels, despite the fact that those channels may be used for downstream transmissions. It is not clear whether CTN is proposing that the 125 kHz channels only be available for response transmissions if all of the 6 MHz channels within 24 MHz are all used for return path transmissions. If so, how will ITFS licensees satisfy their need for response paths if one or more of the 6 MHz channels within 24 MHz of 2686-2690 MHz are used for downstream transmissions? If not, how can CTN square the purported need for a 24 MHz guardband between upstream and downstream transmissions with its proposal to permit upstream and downstream use on nearby channels, including immediately adjacent channels?

In addition, confusion has been introduced because, according to the CTN Request, it is contemplated that "[t]he spectrum from 2,686.00 MHz through 2,689.875 MHz would *continue* to be available only to ITFS stations for talkback channels . . . ." *Id.* at ¶ 7 (emphasis added). However, at present that band is not allocated exclusively for ITFS usage. In fact, only 20 of the 125 kHz

CTN “generally supports the proposed use of ITFS and MDS spectrum for two-way transmission,” the CTN Request expresses a concern that the deployment of response transmitters will cause what CTN calls “brute force overload” interference to ITFS receive sites.<sup>113/</sup> The problem envisioned by CTN is the result of decisions by many ITFS licensees to employ block downconverters (“BDCs”) at their receive sites -- downconverters that are capable of receiving a broad band of channels that includes channels other than those licensed to the ITFS licensee.<sup>114/</sup> To preclude interference to such BDCs, CTN proposes a specific approach to “refarm” the E, F, G and H Group MDS and ITFS channels in a manner that will promote the establishment of a 24 MHz guardband between response channels and ITFS channels.<sup>115/</sup> Apparently, CTN believes that this guardband is necessary to promote the use of filters and downconverters with improved immunity to BDC overload as mechanisms for avoiding the anticipated interference.<sup>116/</sup> While CTN is to be applauded for drawing

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channels are allocated for use by ITFS, while four are allocated to the MMDS channel licensees and the remainder are allocated for private radio use. *See* 47 C.F.R. §101.147(a). Is CTN really proposing that much needed capacity be reallocated away from MDS licensees — many of whom purchased their rights to the 125 kHz channels associated with the E and F Group primary channels at auction? If that is CTN’s intent, how does CTN intend to provide recompense? And, how does CTN propose to allocate those channels to ITFS licensees? Unfortunately, the CTN Request does not address those issues.

<sup>113/</sup> CTN Request, at 2.

<sup>114/</sup> The issue of BDC overload is not a new one for the Commission. Indeed, just several months ago the Commission addressed a similar problem when the wireless cable industry raised concerns over potential downconverter overload resulting from high-power WCS operations in close proximity to wireless cable receive sites. *See WCS Reconsideration Order*, 12 FCC Rcd 3977 (1997).

<sup>115/</sup> *See* CTN Request, at 4-8

<sup>116/</sup> *See id.*, Engineering Statement, at ¶ 5.



attention to two approaches for controlling interference (e.g. the use of filters and/or specialized downconverters), the Petitioners generally believe both that the potential for ITFS receive sites to suffer the sort of interference feared by CTN is minimal, and that CTN has focused on just two of the many possible techniques that a newcomer can employ for assuring that interference does not occur, excluding others that are likely to be more efficient in particular situations.

1. *The Potential For Interference From Response Stations Caused By Downconverter Overload Is Minimal.*

CTN's fear is that although the transmitter/receiver unit that will be installed at each subscriber's premises (the "transceiver") will operate at relatively low power levels, the potential nonetheless exists for the first active device of ITFS receiving systems to operate in a non-linear fashion from the combined radio frequency energy present if transceivers are located in close proximity to the ITFS reception antenna.<sup>117/</sup> In response to a series of discussions between representatives of the Petitioners and CTN over the past several months, the Petitioners have extensively analyzed the potential for overload of the inexpensive broadband BDCs favored by many ITFS licensees and have concluded that the risk of interference is *de minimus*.<sup>118/</sup>

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<sup>117/</sup> See *id.*, Engineers Statement, at ¶ 1 n \*.

<sup>118/</sup> Although CTN has only raised the potential for BDC overload, it is worth noting that there is also a *de minimus* potential for interference to result from third order intermodulation ("IMD"). As a result of limitations in the BDC, it is theoretically possible that IMD may result in the rare case where two transceivers are closely-spaced to the ITFS receive site and operate simultaneously on separate frequencies that combine in such a way to produce a distortion product within the passband of the desired signal. The risks of such interference are minuscule. It will be the rare case indeed when two transceivers will be sufficiently close to an unfiltered BDC and will be operating simultaneously on the particular frequencies that IMD interference will result. This is particularly so since system operators can control the frequencies on which nearby transceivers operate so as to avoid the problem in its entirety. Moreover, all of the mitigation techniques

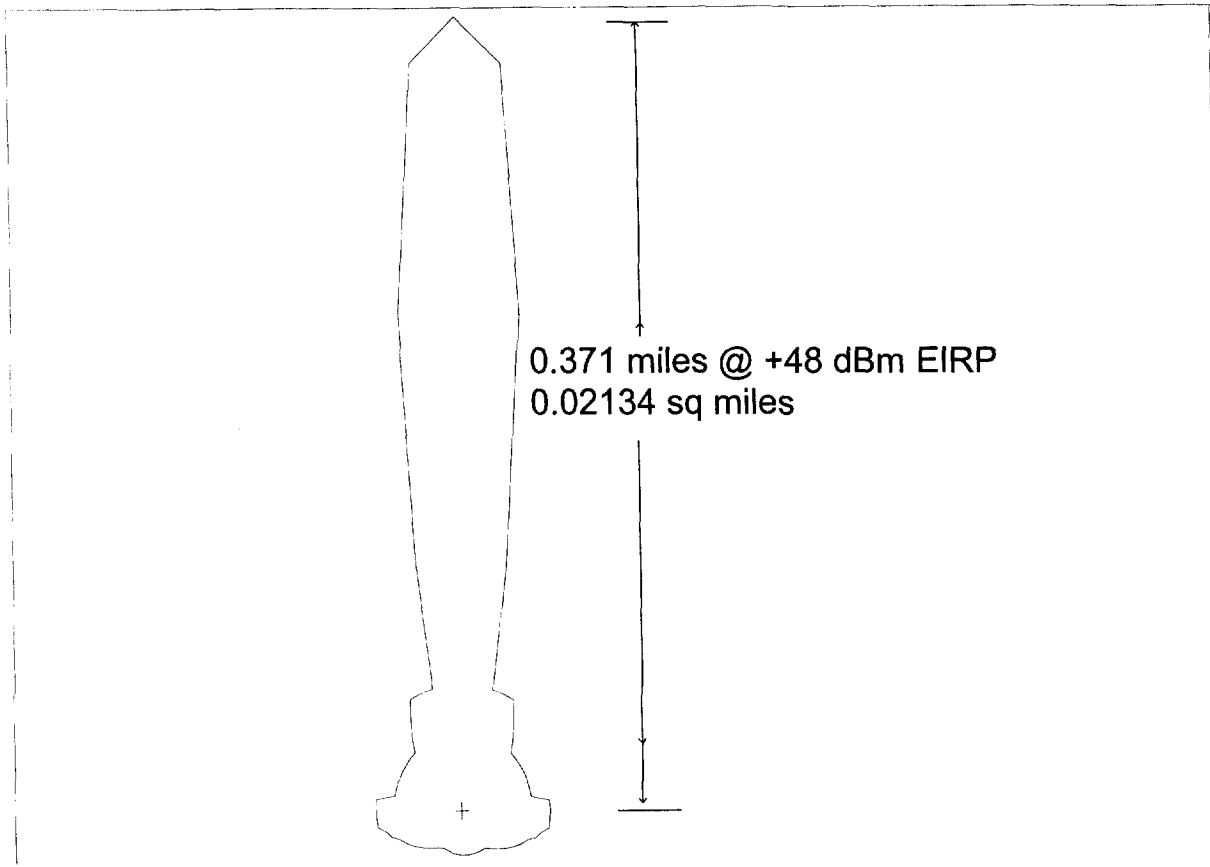
The potential for brute force overload to occur to an ITFS or MDS downstream receive site from a nearby transceiver is a function of many variables. Such elements as the upstream EIRP, the transmit and receive antenna patterns and their polarizations, the location of the transceiver relative to the ITFS receive site and, most importantly, the characteristics and capabilities of the BDC at the ITFS receive site all play a significant role in determining the potential vulnerability of any site to interference (absent application of the many mitigation techniques available).

In attempting to demonstrate the potential for interference, CTN has assumed an extreme scenario — the transmit and receive antennas are co-polarized, precisely bore-sighted and separated by a mere 50 feet, the EIRP of the transceiver is +48 dBm, and the BDC overload point is -28 dBm. The Petitioners concede that, in the absence of the myriad of other interference mitigation techniques discussed below, downconverter overload would occur under this scenario (although it would be curable). However, *detailed analyses conducted by the Petitioners demonstrate that under any realistic scenario, ITFS receive sites located in less than 1% of a PSA would even be at risk, and mitigation techniques generally can eliminate any interference at those few sites!*

Under the scenario portrayed by CTN, the level of the interfering signal would result in the BDC overload point being exceeded by 32 dB. In other words, the potential for overload can be eliminated entirely merely by separating the two antennas until the free space path loss increases to

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discussed below save for attenuation (such as antenna offset, improved BDC dynamic range, notch filters and bandpass filters) can be utilized to prevent IMD interference. As with BDC overload, the appropriate regulatory response to IMD or any other similar interference should be simple — *the licensee of the response station hub should be responsible for curing any interference that results to a protected MDS or registered ITFS receive site that was installed prior to the installation of the transceiver.*



**Figure 1. Bore sighted area of Interference with FCC antenna**

32 dB. Figure 1 illustrates the area where, assuming the use of the FCC standard receive antenna specified in Section 21.902(f)(3) of the Rules, the installation of co-polarized a transceiver operating at +48 dBm and pointed at the ITFS receive site, and line-of-sight conditions, the use of the mitigation techniques discussed in the following section to avoid interference may be required.

As shown, *the size of the area where the installation of a transceiver would even require the application of mitigation techniques is a mere 0.02134 square miles!* Indeed, even if the Commission adopts the Petitioners' proposal to permit transceivers to operate at a maximum of +63 dBm EIRP with a 2 watt transmitter power output limit, the size of the area where the installation of a transceiver using an FCC reference antenna and operating at the power limit would require the

application of mitigation techniques in just 0.06725 square miles. More significantly, where the transceivers operate with an EIRP of +57 dBm (which reflects the use of a 2 watt transmitter coupled to a 24 dBi antenna, which the Petitioners suspect will be employed far more often than transceiver systems capable of transmitting the maximum allowable EIRP) the size of the area where the installation of a transceiver would require the application of mitigation techniques will be a mere 0.184 square miles.

It must be remembered that these calculations assume that the transceiver antenna is bore-sighted to the ITFS receive antenna. However, logic dictates that the probability of actually having a bore-sighted pair of antennas is extremely low. As a practical matter, the number of hub sites and their location relative to the ITFS transmitter will dictate whether areas exist where the potential for bore-sighted conditions occur and, if so, the size of those areas. As the transmit and receive antennas deviate from a bore sighted condition, the sidelobe suppression of the antennas quickly causes the interference potential to diminish and the area shown in Figure 1 to decrease rapidly.

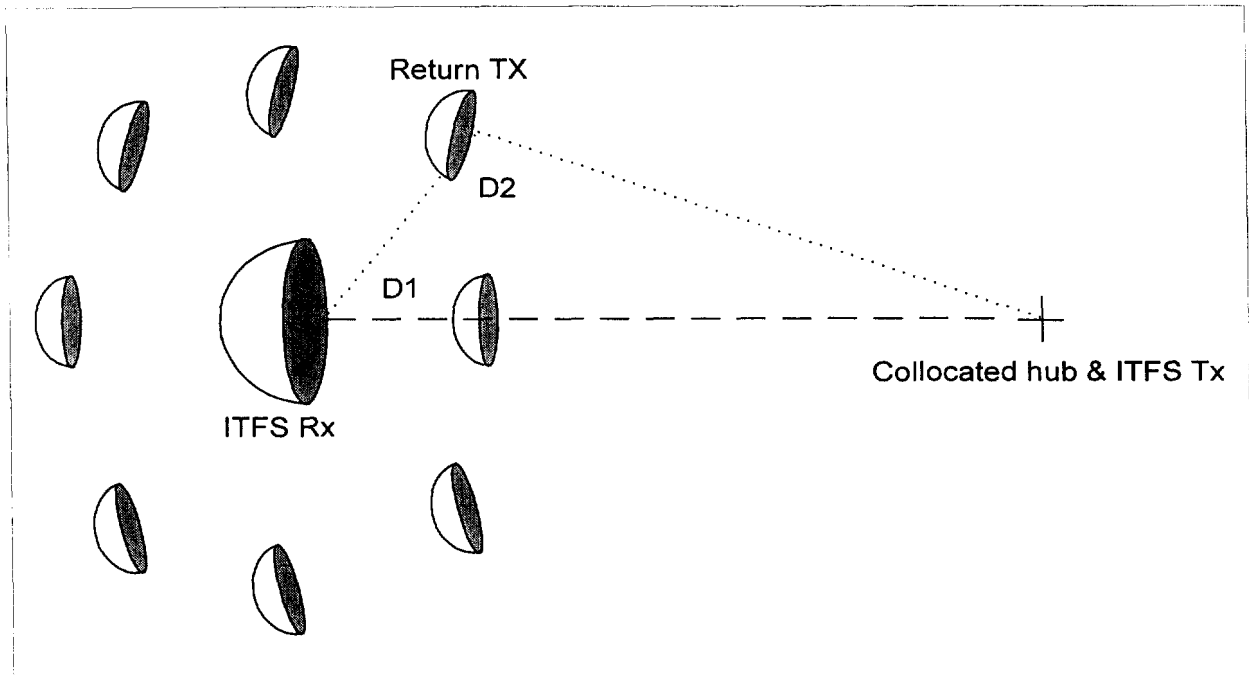
To demonstrate how rare it will be for bore-sighted conditions to occur in the operating environment, several different system architectures were examined by the Petitioners' technical consultants. The first architecture consisted of a collocated downstream transmitter and upstream response station hub site. This architecture will be prevalent in many system designs, as most operators of two-way systems will try to use their existing downstream transmission sites for collecting upstream return signals. The other architectures examined were hypothetical cellular designs consisting of 5 evenly-distributed hub sites and 10 evenly-distributed hub sites respectively, as well as the actual 3-hub design being deployed in Phoenix. As the number of hub sites increases,

the potential for creating bore-sighted conditions will increase. However, in normal system designs as the number of hub sites increases the size of the cell served by each hub site will decrease. As the size of the cell decreases, in the real world the EIRP of the return path transmissions will decrease. However, for purposes of these hypothetical studies the EIRP of the return path transmitters was not decreased.

For the hypothetical architectures described above, 1000 ITFS receive sites were randomly distributed throughout the 35 mile PSA, a conservative approach given that the Petitioners are unaware of any area with the country that has that quantity of ITFS receivers within a PSA. For the analyses conducted of the actual system architecture currently being proposed for Phoenix, the actual ITFS registered receive sites were analyzed for potential interference.

#### **System Architecture 1 – Hypothetical Collocated Hub and Downstream Transmit Site**

In many situations, a response station hub will be collocated with an ITFS downstream transmit site. Figure 2 below illustrates the configuration of a typical ITFS receive site and several possible positions of transceivers around that ITFS receive site in such a situation.



**Figure 2. Configuration of antennas for collocated hub and ITFS transmit site.**

Let D1 above represent the discrimination angle at the ITFS receive site between the ITFS transmit site and the return path transmitter. Let D2 represent the discrimination angle at the return path transmit site between the hub site and the ITFS receive site. A combination of the discrimination from angle D1 at the ITFS receive antenna and the discrimination caused by angle D2 at the return path transmit antenna provides the total discrimination the ITFS receive site will receive.

Looking at the various positions the return path transmit sites can take around the ITFS receiver, one quickly realizes the total discrimination angle ( $D1+D2$ ) is always very close or equal to 180 degrees. Therefore, every possible configuration of the return path transmitter results in a high degree of discrimination between antennas. At positions where the transmit and receive

antennas are in line with the hub and transmit site ( $D1=0$  or  $D2=0$ ), the minimum amount of attenuation is achieved. This is represented by the front-to-back ratio of the antennas. If we assume FCC reference antennas for both the upstream transmit and the downstream receive antennas, the total attenuation is 25 dB (which is the front-to-back ratio of the FCC reference antenna).

At 25 dB attenuation to the upstream signal, the area where interference mitigation techniques may be needed, as shown previously in Figure 1, for a +48 dBm EIRP upstream signal shrinks to a length of 0.021 miles and the total area is <0.0001 square miles. If there are 1000 randomly-distributed receive sites in the 35 mile protected service area, this represents less than 0.003% of the service area.<sup>119/</sup> In other words, the variety of other mitigation techniques discussed below will only need to be considered in connection with the installation of transceivers in 0.003% of the PSA (assuming that all transceivers operate at +48 dBm EIRP, which will not occur in the operating environment). If the EIRP of all of the transceivers is assumed to be an even more unlikely +63 dBm (which, given the proposed 2 watt transmitter output power restriction can only be achieved through the use of a very high gain, directional antenna that will itself tend to mitigate the potential for BDC overload), the total area where mitigation techniques even need to be considered is a mere 0.0004 square miles per ITFS receive site, or less than 0.01% of the entire PSA if 1000 ITFS receive sites are installed.

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<sup>119/</sup> Although the randomly-distributed receive sites may have had overlapping areas where mitigation techniques may be called for, no adjustment was made to eliminate “double counting” of such areas. Thus, the size of the mitigation area may be over-estimated because it is possible in the field that two ITFS receive sites will be so closely spaced that their mitigation areas will overlap.

As is discussed in more detail at page 94, one of the mitigation techniques that can be employed to eliminate BDC overload is to employ antennas with greater sidelobe suppression. As the Commission considers just how unlikely it is that downconverter overload will occur in the field, it should recognize that if the performance of both antennas is improved to a typical 24 dBi antenna with a front-to-back ratio of >32 dB (which are often used at ITFS receive sites, and could readily be used as response station transmit antennas), there will be absolutely no area whatsoever where there is even a potential of downconverter overload from a return path transmitter operating at +48 dBm or less. When a maximum power 2 watt transceiver is coupled with one of these 24 dBi antenna, the area where mitigation techniques must be considered will be reduced to just 0.0001 square miles per ITFS receive site, which represents just 0.03% of the PSA (assuming that 1000 ITFS receive sites are installed).

### **System Architecture 2 – Hypothetical Five Cells**

Attached as Exhibit 1 is a diagram of a theoretical system architecture for a two-way system utilizing five cells to serve a 35 mile PSA. The two-way system is overlaid with an ITFS system where there is a single ITFS downstream transmit site located at the center of the PSA, which serves 1000 ITFS receive sites distributed randomly throughout the PSA.

Figure 3 below is a closer examination of one of the five cells and the directionality relationship of a potential ITFS receive antenna and return path transmit antennas located throughout the cell. As can be seen from Figure 3, within a majority of the area of the cell the angle between an ITFS receive antenna directed at the ITFS transmit site and a return path transmit antennas directed at the hub is large. Not until one approaches the area directly between the hub and the ITFS



transmit site do the discrimination angles get sufficiently small that a bore-sighted condition could occur.

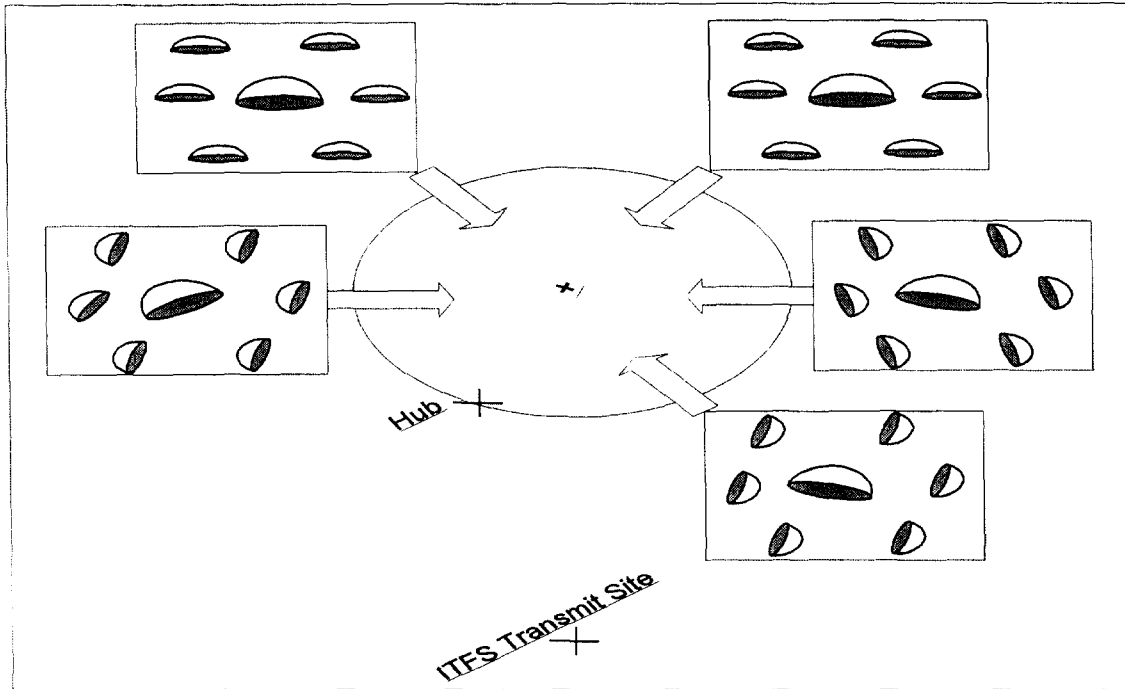


Figure 3 -- Examination of one cell and antenna orientations.

As a result of the additional signal attenuation that results from antenna discrimination, the area around each ITFS receive site, as illustrated by Figure 1, where the installation of a transceiver would call for mitigation techniques for most of the cell is significantly less than the area around an ITFS receive site where there is a bore sighted condition. Based on Figure 3, the cell can be divided into regions with increasingly smaller areas where interference mitigation techniques will need to be considered, as a result of the additional attenuation from the antenna discrimination. Regions within the cell can be identified where the antenna discrimination will provide 3, 6, 12 and 18+ dB of additional attenuation. Because the size of these areas is extremely small when a 31 dB antenna is employed an additional region at 24 dB of discrimination was added. For the 5 cell design, these regions are shown in the attached Exhibit 2. As expected, these regions are clustered around the area of each cell in line with the hub site and the ITFS transmit site. Table 1 below lists the number of receive sites located within each region and the size of the potential area of interference (absent the use of mitigation techniques and assume line-of-sight conditions) for each region. FCC standard, 12 dBi, 24 dBi and 31 dBi antennas are analyzed and the EIRP is set by using a 2 watt response transmitter output power, not to exceed +63 dBm EIRP total. Of course, as noted above, particularly in a multi-cell design, the use of such an EIRP is highly unlikely. Yet, as Table 1 shows, the potential area where mitigation techniques must be employed is extremely small even assuming

Attn (dB)	FCC Antenna Max EIRP = +53 dBm				24 dBi Antenna Max EIRP = +57 dBm				Length (mi)
	Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area SubT (mi <sup>2</sup> )	Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area SubT (mi <sup>2</sup> )	
0	0.661	0.0673	8	0.538	1.66	0.1841	8	1.4728	0.104
3	0.4677	0.0339	5	0.1697	1.175	0.0931	4	0.37236	0.0741
6	0.331	0.0172	3	0.05166	0.832	0.0472	2	0.09436	0.0525
12	0.166	0.0043	7	0.02982	0.417	0.0116	0	0	0.0263
18	0.0832	0.001	61	0.061	0.209	0.0029	5	0.01467	0.0132
>18	0.0832	0.001	916	0.916	0.209	0.0029	981	2.878254	0.0132
24									
>24									
			Total:	1.766				Total:	4.832
			%:	0.05%				%:	0.13%

12 dBi Antenna Max EIRP = +45 dBm				31 dBi Antenna Max EIRP = +63 dBm			
Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area SubT (mi <sup>2</sup> )	Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area SubT (mi <sup>2</sup> )
0.104	0.0055	8	0.04436	7.852	1.711	8	13.688
0.0741	0.0028	53	0.1484	5.559	0.8653	0	0
0.0525	0.0014	23	0.03197	3.935	0.4294	2	0.8588
0.0263	0.0003	26	0.009048	1.972	0.1076	3	0.3228
0.0132	9E-05	42	0.00378	0.989	0.0282	3	0.0846
0.0132	9E-05	848	0.07632				
				0.495	0.007	19	0.133494
				0.495	0.007	965	6.78009
		Total:	0.314			Total:	21.868
		%:	0.01%			%:	0.57%

**Table 1. Size of potential area requiring use of mitigation techniques for 5 cell design.**

maximum return path EIRP for each antenna.

### **System Architecture 3 – Hypothetical Ten Cells**

A similar approach can be taken with respect to a hypothetical system employing 10 cells to serve its 35 mile radius PSA. Attached as Exhibit 3 is a diagram of a ten cell approach again overlaid with an ITFS station using a single transmit site and 1000 ITFS receive sites randomly distributed throughout the service area. A determination of the areas where mitigation techniques may be required will follow the same logic as described above with respect to the 5 cell design, and are shown in Exhibit 4 for the two antenna types. The region shown with 25 dB and 32 dB of attenuation represents the ITFS receive sites located in the cell at the center of the service area with attenuation equal to the front-to-back ratio of the antennas as described in System Architecture 1.

Table 2 shows the results of the distribution of the ITFS receive sites within the various

Attn (dB)	FCC Antenna Max EIRP = +53 dBm				24 dBi Antenna Max EIRP = +57 dBm				
	Length (mi)	Area (mi2)	# of Rx Sites	rea Subtot (mi2)	Length (mi)	Area (mi2)	# of Rx Sites	rea Subtota (mi2)	
0	0.661	0.06725	3	0.20175	1.66	0.1841	3	0.5523	
3	0.4677	0.03394	31	1.05214	1.175	0.09309	25	2.32725	
6	0.331	0.01722	3	0.05166	0.8318	0.04718	11	0.51898	
12	0.166	0.00426	21	0.08946	0.417	0.01162	10	0.1162	
18	0.08317	0.001	107	0.107	0.2089	0.00293	11	0.032274	
>18	0.08317	0.001	739	0.739	0.2089	0.00293	844	2.476296	
24									
>24									
25	0.03715	0.00022	96	0.02112					
32					0.042	0.00012	96	0.01152	
38									
			Total:	2.262				Total:	6.03482
			%:	0.06%				%:	0.16%

12 dBi Antenna Max EIRP = +45 dBm				31 dBi Antenna Max EIRP = +63 dBm			
Length (mi)	Area (mi2)	# of Rx Sites	rea Subtota (mi2)	Length (mi)	Area (mi2)	# of Rx Sites	rea Subtota (mi2)
0.104	0.00555	3	0.016635	7.852	1.711	3	5.133
0.0741	0.0028	115	0.322	5.559	0.8653	6	5.1918
0.0525	0.00139	37	0.05143	3.935	0.4294	0	0
0.0263	0.00035	37	0.012876	1.972	0.1076	16	1.7216
0.01318	0.00009	27	0.00243	0.989	0.0282	12	0.3384
0.01318	0.00009	678	0.06102				
				0.4954	0.007	23	0.161598
				0.4954	0.007	837	5.880762
0.00525	0.00001	103	0.00103				
				0.0989	0.0004	103	0.03708
		Total:	0.467421			Total:	18.46424
		%:	0.01%			%:	0.48%

**Table 2. Size of potential area requiring use of mitigation techniques for 10 cell design.**

attenuation regions and the total percentage of area where mitigation techniques will need to be considered. Again, the area where mitigation may be called for is extremely small.

#### **System Architecture 4 – Phoenix Two-Way System Design**

To avoid any criticism that their analysis is based on hypothetical system designs, the Petitioners also undertook an analysis of the potential for downconverter overload employing the design of the system authorized for operation by PCTV in Phoenix, which will employ a 3 cell design as is shown in Exhibit 5.<sup>120/</sup> The 35 mile PSA serves as one response service area, with the hub site located at the center of the cell and collocated with all ITFS stations in the region. Two additional cells will be located to the north and northeast. The northern most cell is approximately 18 miles in diameter and has the hub located on the cell perimeter at approximately 220 degrees from true north. The third cell is approximately 16 miles in diameter and has the hub located at the center of the cell. The actual location of all 208 registered ITFS receive sites within the 35 mile radius service area are also plotted on Exhibit 5.

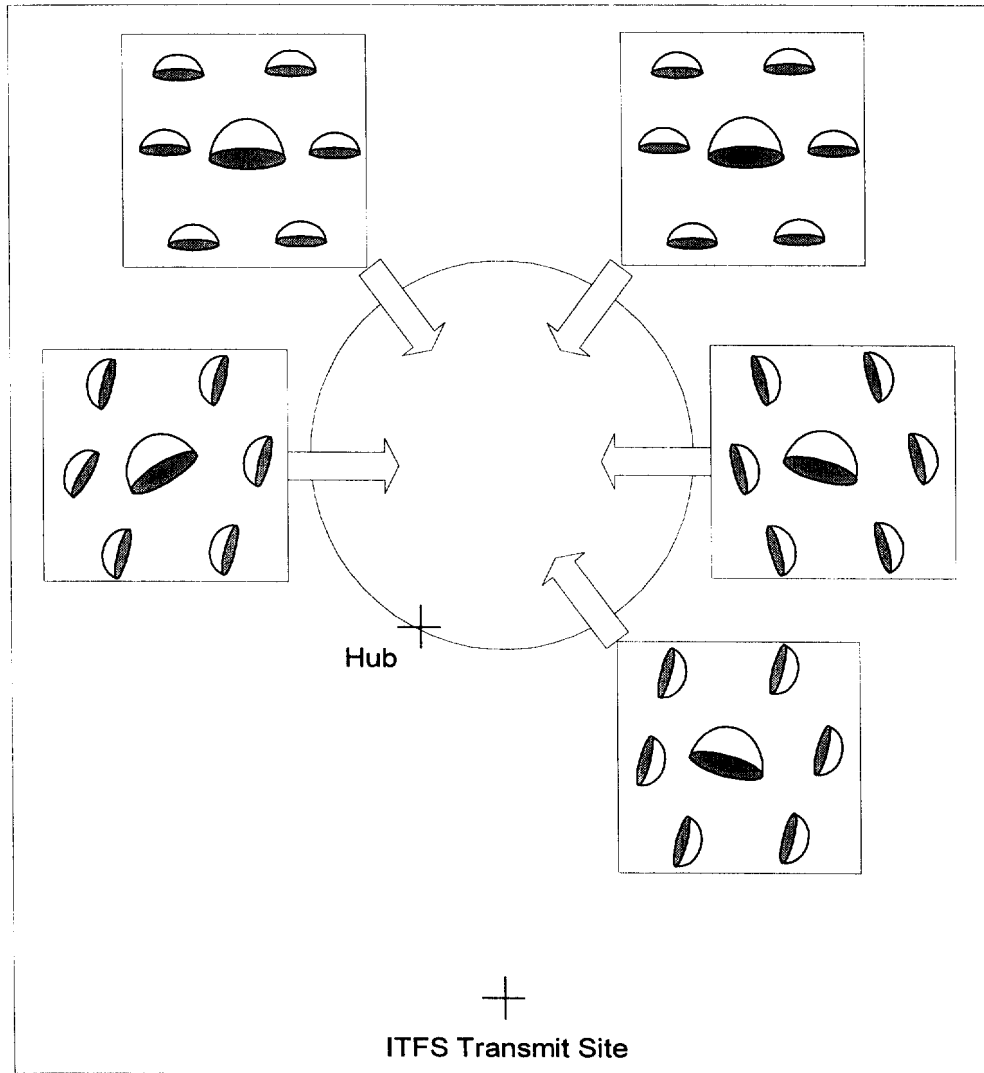
All receive sites located in the main 35 mile radius cell, but not in either of the two smaller cells, will exhibit an area of where mitigation techniques will need to be considered along the same lines as is described in connection with System Architecture 1. Every receive site will have an antenna relationship as shown in Figure 2. For the northeastern cell (which only includes four ITFS receive sites), the areas of potential interference will follow the shape described in System

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<sup>120/</sup> Although the Phoenix system is currently designed to operate response transceivers on MDS Channels 1 and 2A, the analysis conducted by the Petitioners assumed that response operations will also be authorized in the 2500-2686 MHz band.

Architecture 2 and shown in attached Exhibit 6. Again, the areas of potential interference around each receive site will vary depending on possible discrimination angle as described in Figure 3.

The northern-most cell (which includes 18 ITFS receive sites) has its hub site located on the perimeter of the cell in a southwestern direction from the cell center. Figure 4 below is a diagram showing the antenna relationships for this cell. As can be seen from Figure 4, the angle between the return path transmit and the ITFS receive antenna varies between 90 to 180 degrees. Therefore, the



**Figure 4. Antenna relationships for northern most cell in Phoenix.**

worst case discrimination would occur at 180 degrees. As a result, the area of where mitigation techniques may have to be employed for the ITFS receive sites located in this cell is controlled by the front-to-back ratio of the antennas.



Table 3 summarizes the potential areas of interference for the ITFS receive sites in Phoenix,

Attn (dB)	FCC Antenna Max EIRP = +53 dBm				24 dBi Antenna Max EIRP = +57 dBm				
	Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area Subtotal (mi <sup>2</sup> )	Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area Subtotal (mi <sup>2</sup> )	
0	0.661	0.0673	1	0.06725	1.66	0.1841	1	0.1841	
3	0.4677	0.0339	1	0.03394	1.175	0.0931	0	0	
6	0.331	0.0172	0	0	0.8318	0.0472	1	0.04718	
12	0.166	0.0043	1	0.00426	0.417	0.0116	0	0	
18	0.0832	0.001	1	0.001	0.2089	0.0029	2	0.005868	
>18	0.0832	0.001	0	0	0.2089	0.0029	0	0	
24									
>24									
25	0.0372	0.0002	204	0.04488					
32									
38									
			Total:	0.151				Total:	0.261628
			%:	0.00%				%:	0.01%

12 dBi Antenna Max EIRP = +45 dBm				31 dBi Antenna Max EIRP = +63 dBm			
Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area Subtotal (mi <sup>2</sup> )	Length (mi)	Area (mi <sup>2</sup> )	# of Rx Sites	Area Subtotal (mi <sup>2</sup> )
0.104	0.0055	1	0.005545	7.852	1.711	1	1.711
0.0741	0.0028	3	0.0084	5.559	0.8653	0	0
0.0525	0.0014	0	0	3.935	0.4294	0	0
0.0263	0.0003	0	0	1.972	0.1076	0	0
0.0132	9E-05	0	0	0.989	0.0282	0	0
				0.4954	0.007	2	0.014052
0.0372	0.0002	204	0.04488				
				0.0989	0.0004	205	0.0738
		Total:	0.058825			Total:	1.725052
		%:	0.00%			%:	0.04%

**Table 3. Areas where mitigation techniques would be considered for Phoenix system.**

assuming all return paths operate with an EIRP of 63 dBm (which, it must be noted again, is